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A Graphical Representation of Temporal Data from Simulations

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A Graphical Representation of Temporal Data from Simulations

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Abstract

The analysis of extremely large data sets is time-consuming and tedious. In this project, we create two tools, the Image Inspector and the Video Inspector, to aid in the automated analysis of 3D temporal data from simulations. Our problem is the 3-dimensional time varying data of the Rayleigh-Taylor instability in a fluid mix problem. We examine the bubble dynamics due to the acceleration of gravity in an initially perturbed interface between a heavier and lighter fluid. Through the use of OpenGL and C++, we automate the capture of the temporal dependence of selected features along a chosen path in a time-dependent 3D simulation. The selected feature, e.g., the height of a bubble, is displayed graphically as a function of position and time. The path can be chosen arbitrarily; differing from previous projects which required the use of horizontal or vertical orientation.

1 Introduction

Scientific simulation often produces large 3D data sets requiring complex analysis. An example of this is time-varying data of the Rayleigh-Taylor instability in a fluid mix problem. This instability is caused by gravitational acceleration in an initially perturbed interface between a heavier and lighter fluid. The acceleration gives rise to bubbles and spikes. Our problem is to understand the bubble dynamics over time. The data sets for the problem are very large. It is extremely tedious to analyze this data manually. We describe two tools to aid in the automated analysis of this data.

In section two, we describe the first tool, the Image Inspector. The Image Inspector is used to analyze single images from a simulation. The Video Inspector is explained in the section three. The Video Inspector, a tool to analyze a series of images from a simulation, has multiple features which aid in data analysis. In section four, we will conclude with future directions for the project.

2 The Image Inspector

The Image Inspector is a tool designed to analyze single images from simulations. Previous tools for simulation image data analysis only gave the ability to examine variation between two points in vertical or horizontal orientation. The Image Inspector gives the ability to examine the variation in intensity between two points in an arbitrary orientation.

Features of the Image Inspector include not only the use of arbitrary orientation, but also the ability to view, pixel by pixel, the path being traced. In addition, a user can examine the output from the Image Inspector in either bar graph or line format. Implemented menus make it easy for the user to switch back and forth between the line graph (Figure 2) and bar graph (Figure 3) views.

The Image Inspector only examines data from a single image. In order to examine the change in data over time, a new tool, the Video Inspector, was developed. The Video Inspector is described in the following section.

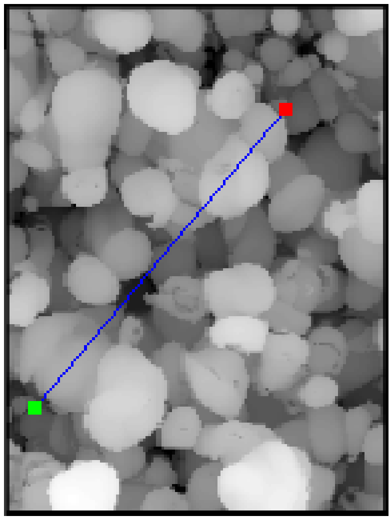


Figure 1: An arbitrary path on a pre-processed image is selected for data analysis.

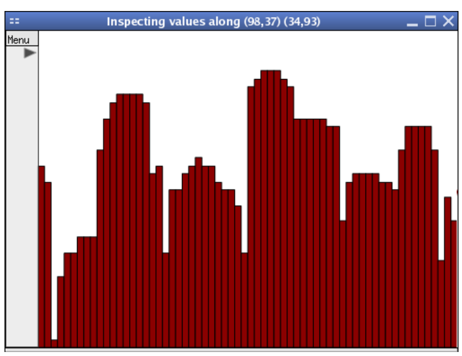


Figure 2: Output from an arbitrary path displayed with a bar graph.

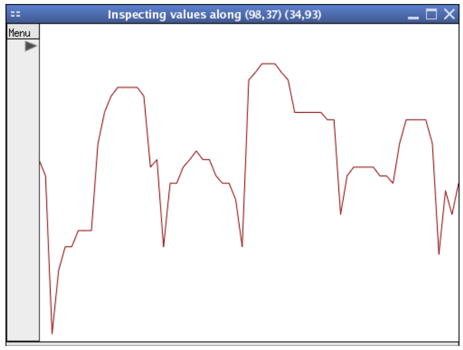


Figure 3: Output from an arbitrary path displayed with a line graph.

3 The Video Inspector

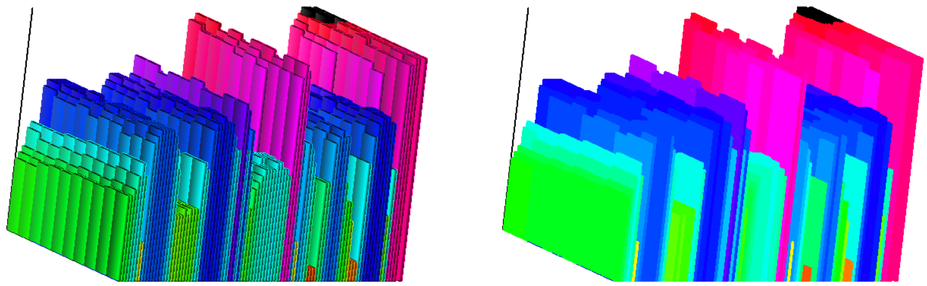
The Video Inspector extends the concept of the image inspector to include time varying data. OpenGL and C++ are used to automate the capture of the temporal dependence of selected features. These features are sampled along a user specified arbitrary path in a time-dependent 3D simulation. The selected features are displayed graphically as a function of position and time.

3.1 Features

The output of the video inspector is a 3D bar plot displaying the selected features, e.g., the height of a bubble in the Rayleigh-Taylor instability problem. Features of the video inspector give users the ability to examine the data in multiple ways which aid in data analysis. The different features include coloring and lighting options, different viewing angles, and optimal data selection. These features are described in the following sections.

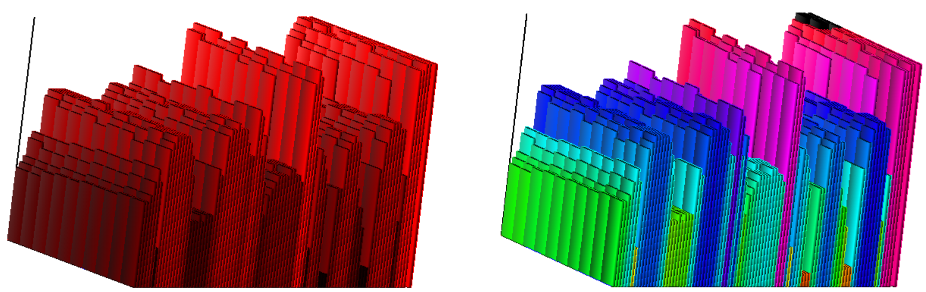
3.1.1 Coloring and Lighting

Different coloring and lighting options for the 3D output plot give users the ability to easily examine data. Using menus, users can turn the lighting on or off (see Figure 4). In addition, users can chose to view the colors of the plot either as a hue map or a saturation (see Figure 5). The coloring choice can be made either using the menu, or toggled using the ”c” key on the keyboard.



(a) Lighting On (b) Lighting Off

Figure 4: Different lighting options aid users in data analysis. The lighting can be turned on or off, using either the menu or keyboard commands.



(a) Saturation (b) Hue Map

Figure 5: The Video Inspector has different color options for user preference. Keyboard commands give users the ability to switch between a hue map and saturation coloring.

3.1.2 Viewing Angles

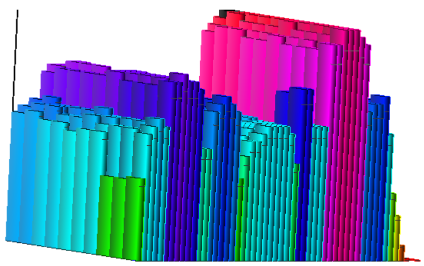
Different viewing angle options give users the ability to examine the data from multiple perspectives. Zoom, rotation, and translate features, controlled by the mouse, make it easy for users to view their data from all possible angles. In addition, a ”top-down” view gives users the ability to clearly see the changes in their data over time. The different views are shown in figure 6.

3.1.3 Data Selection

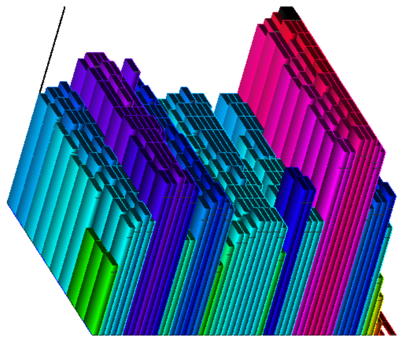
In addition to manipulation of the color, lighting, and viewing angles of the 3D output plot, users have the ability to chose how much of the data they wish to view at at given time. Users can run through entire simulations at one time to create the output, or they can navigate through their simulations manually. The manual navigation produces a time-incrementing output view (see Figure 7). In addition, users can control which frames of their simulation are viewed in the video inspector output.

4 Conclusion and Future Work

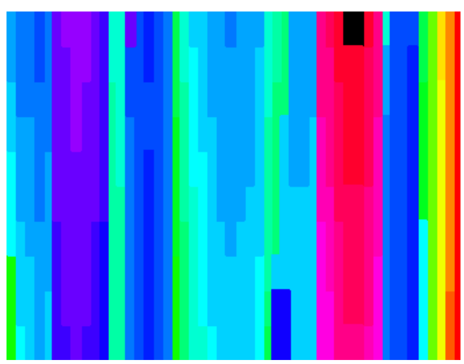
The Image and Video Inspectors are useful tools for automated analysis of large amounts of data. The Image Inspector creates either a line graph or bar graph output of the values of a selected feature from the data over a specified path. The Video Inspector expands on the concept of the Image Inspector, creating a 3D bar plot representation of the change in a selected feature over a specified path and as a function of time. Future work includes usability improvements to the Image and Video Inspectors.



(a) Default View

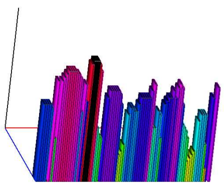


(b) Rotation

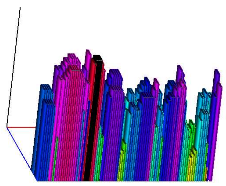


(c) Top Down

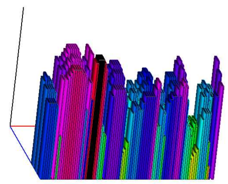
Figure 6: Multiple viewing options aid users in data analysis. Users can rotate, translate and zoom the 3D view using the mouse, or select a fixed top down view. The view is reset to the default using either the keyboard or the menu.



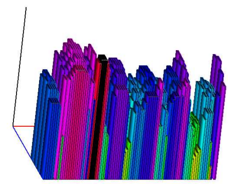
(a) Time 1



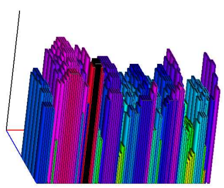
(b) Time 2



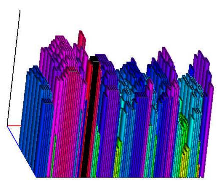
(c) Time 3



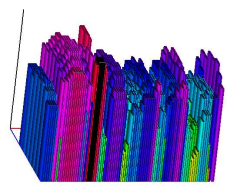
(d) Time 4



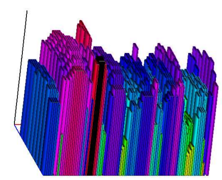
(e) Time 5



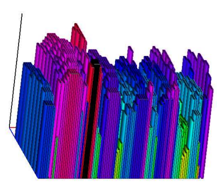
(f) Time 6



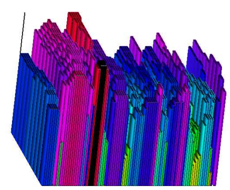
(g) Time 7



(h) Time 8



(i) Time 9



(j) Time 10

Figure 7: The user can manually navigate through the simulation. This navigation produces a time-incrementing output view. The figures show the navigation between 10 simulation frames.